

A Virtual Control Room for CMS

Compact Muon Solenoid (CMS)

- Experiment at LHC (Large Hadron Collider) to study pp collisions
- Large collaboration
 - Total: 154 institutions and ~2000 collaborators worldwide
 - US: 36 institutions and ~500 collaborators (Sept 2002)**
- Size of collaboration increasing
- Expect rapid increase as turn-on date nears (**April, 2007**)
- D0 doubled in size around the time of first data taking
- Expect a large number of collaborators from CDF and D0

Travel Cost

- Current annual programmatic travel ~ **\$500 K**
- Expect **~1000 or more US collaborators** by 2007
- Large **increase in travel cost**
 - shift responsibilities
 - detector commissioning, troubleshooting
 - meetings
 - etc
- **Possible to reduce this cost ?**

Travel Cost (cont)

- **Possible**
 - US collaborators **can actively participate** in CMS data-taking shifts **remotely**
 - Will require **close coordination** between individuals on shift in US and CERN.
 - Necessary environment should give the remote individuals **the perception that they are all in the same room.**

Travel Cost (cont)

- This environment we call a **virtual control room**.
- Any system good for **remote shift-taking** will be good for
detector commissioning, troubleshooting
meetings
LHC accelerator studies (from US)
etc.

US CMS Physics Analysis Center

- **CMS Tier1 data center** in Fermilab
- Provides experiment data to the **Tier2 centers** and eventually to **all the institutions**
- Existence of a virtual control room in Fermilab
- Aid in **establishing a US HEP center** for CMS Physics with a critical mass of physicists (analysis)
- **Reduced travel**

Past Remote Shift Attempt

- Idea of taking shifts remotely around for some time
- **CDF's proposal** (~ 1995) for remote shifts from Japan (KEK)
- Quickly abandoned after a few trials

Only monitored experiment data over the network

The **fundamental issues of human interaction** between the people on shift went **unaddressed**

Typical Shift: an Example

- An experiment: **CDF**
- A **shift team** consists of 5 individuals
- 4 individuals **in the same room**
- Rely on **human communications** to **synchronize** their activities
- **Speech** and **Vision**
- For remote participation in a shift operation, he/she should be able to **communicate** with others in **in the same manner** as those physically present in the room.

Virtual Control Room

- **Remote shift taking**: provide an environment in which remotely located individuals **have a perception** of being in the same room.
- Goal: build an **affordable** virtual control room
- Technologies for a virtual control room **available** today
 - Gigabit networking, HDTV
 - Display technologies, processors, codecs, etc
- **Avoid customized components** (hardware/software)

Virtual Control Room (cont)

Speech

- Is it possible to have a **normal** conversation between remotely located individuals in Fermilab and CERN ?

Table 1: Effects of latency on human ear perception

one-way latency	effects of delay
> 600 ms	speech incoherent and unintelligible
250 ms	speech annoying
100 ms	effect imperceptible if listener hears only from network and not off the air
50 ms	effect imperceptible even if listener in same room and can hear naturally from the air and off the network

Speech

- Magic number: **50 ms one-way latency** (100 ms round-trip)
- Distance between Chicago and Geneva: **~8000 Km**
speed of light (**glass fiber**): $\sim 2 \times 10^5$ Km/sec
one-way latency: ~ 40 ms
- Achieving 100 ms round-trip latency may be difficult
- < 200 ms possible (little over 100 ms)
- ping lxplus.cern.ch: **round trip time ~ 190 ms**
- Bandwidth not an issue
- compressed digital stereo sound: **~ 0.5 Mb/sec**

Virtual Control Room (cont)

Visual

- **Human perception** of real world is 3d
- Ideally want a **holographic projection** of remote location and individuals (Star Trek!)
- Not possible today
- Possible to **impart a sense of realism** (HDTV) using high resolution 2D displays
realistic colour reproduction

Visual (cont)

- **Smooth motion** necessary for a sense of realism
cinema: 24 frames/sec, NTSC TV: 30 fps, HDTV: 60 - 75 fps
- bandwidth ~ **20 Mb/sec (dedicated)** one stream
two streams ~ 40 Mb/sec
- Wide screens (HDTV) impart **depth perception**
a 3d feeling
flat panel displays, projection HDTV
- Work focus
visual projection (placement, number of cameras, etc.)
minimisation of latency (network)
- May be possible to make remote location appear as
extension of the local control room.

Status & Benefits

- High bandwidth network the driving force
- Fermilab has **2 OC-3 (155 Mb/sec) links** to the world
- Plans to upgrade these to **OC-12 (622 Mb/sec) links** soon
- Talk of **dark fiber** from Chicago to Europe (DWDM)
- Other **components are affordable**
- **63" flat panel plasma display (Samsung) ~ \$16000**
- **Cost decreasing rapidly** (driven by consumer market)

Status & Benefits (cont)

- CMS **virtual room** currently in study stage
- Can afford to shoot for the sky
- Once initiated, **move rapidly**
- Consult with experts (**Lucent, CAVE project** in UIC)

Status & Benefits (cont)

- **Benefits too many** to let the project fall by the wayside
 - Absence of travel to CERN for shifts
 - Able to have “live” meetings with people at CERN
 - Ability to troubleshoot detectors remotely
 - Detector commissioning remotely
 - Conduct LHC accelerator experiments from the US
- If cost low, **install several virtual control rooms** in the US